# Double-chimney technology for treating secondary type I endoleak after endovascular repair for complicated thoracic aortic dissection

**Rui Feng, MD, PhD, Zhiqing Zhao, MD, Junmin Bao, MD, PhD, Xiaolong Wei, MD, Liang Wang, MD,** and **Zaiping Jing, MD, PhD,** *Shanghai, P.R. China*

**Endovascular repair continues to pose a formidable technical challenge in the cases of aneurysm, dissection, and proximal type I endoleak involving the aortic arch. During the process of covering the aortic arch by stent graft to achieve better sealing, maintaining blood flow to the vital supra-aortic branches is difficult. We present a case of successful endovascular treatment of secondary type I endoleak by a double-chimney technique in a 36-year-old woman who had previously undergone a complicated descending aortic dissection repair. This endovascular technology might offer a new option to simultaneously preserve the innominate artery and the left carotid artery for total reconstruction of the aortic arch. (J Vasc Surg 2011;54:212-5.)**

Thoracic endovascular aortic repair (TEVAR) has been developed as a safe and effective treatment modality for descending thoracic dissection and aneurysm.[1,2] However, endovascular therapy is very difficult when the aortic arch is involved or a type I endoleak is present. The main challenge lies in maintaining blood flow to the vital supra-aortic branches while the arch is being covered by the stent graft. We present a case of successful double-chimney endovascular repair of a severe secondary proximal type I endoleak after TEVAR.

## CASE REPORT

The patient was a 36-year-old woman who had been experiencing intermittent chest pain for 8 years. Computed tomography angiography (CTA) and aortography showed a complicated Stanford type B aortic dissection with a maximum diameter of 6 cm (Fig 1, *A*). The entry tear was located in the origin of the descending thoracic aorta 2 cm from a severe arch stenosis and angulation. The dissection extended to the renal artery, and the true lumen of the thoracoabdominal aorta was compressed into a string. She had significant medical comorbidities, including hypertension, congenitally narrow iliofemoral arteries, and a severe stenotic lesion at the trachea, for which an open surgery had been withheld at another hospital.

From the Department of Vascular Surgery, Changhai Hospital, Second Military Medical University, Institute of Vascular Surgery of Chinese People's Liberation Army, Clinic Center of Vascular Diseases of Shanghai, and National Key Department of Vascular Surgery of P.R. China.

This work was supported by the National High Technology Research and Development Program of China.

Competition of interest: none.

Reprint requests: Zaiping Jing, MD, PhD, Department of Vascular Surgery, Changhai Hospital, 168 Changhai Road, Shanghai 200433, P.R. China (e-mail: jingzp@xueguan.net).

The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a competition of interest.

0741-5214/$36.00



doi:10.1016/j.jvs.2010.11.120

The first TEVAR was performed with the patient under general anesthesia via a laryngeal mask airway. The distal aorta was exposed via laparotomy, and a 10-mm expanded polytetrafluoroethylene (ePTFE) access conduit was anastamosed to the aortic bifurcation. After stenting, the compressed true lumen of the thoracoabdominal aorta with a 22 mm × 60 mm self-expandable Sinus uncovered stent (OptiMed Medical, Ettlingen, Germany), a 30 mm × 155 mm Relay stent graft (Bolton Medical, Sunrise, Fla) was deployed with the margin of the fabric close to the left subclavian artery (LSA). Since the young patient was left-handed, we wanted to preserve the LSA at that time. However, the subsequent aortography revealed a mild proximal type I endoleak. This problem was fully resolved by placement of a 32 mm × 80 mm HERCULES cuff (Microport Medical, Shanghai, China) with partial covering of the LSA (Fig 1, *B*). The cuff consists of a nitinol stent and a Dacron graft with an uncovered proximal end. No abnormalities were discovered during the pathologic examination of the abdominal aortic wall. However, according to aortic dissection and congenitally narrow iliofemoral arteries of the young female patient, the fibromuscular dysplasia was mostly suspected.

The patient recovered with good blood pressure control. A follow-up CTA performed 3 months after the operation revealed patent aortic flow and complete thrombosis in the descending false lumen. Six months after the operation, she experienced similar chest pain, and CTA showed the presence of a severe secondary proximal type I endoleak (Fig 2). There was no visible change in the endograft morphology, and the aortic stenosis and angulation remained as they were originally. We attributed the endoleak to the severe arch stenosis and angulation, which resulted in insufficient stent graft sealing.

We, therefore, decided to perform the second intervention with the intention of covering the innominate artery and the left common carotid artery (CCA) to gain a longer landing zone and better orientation for stent graft delivery. The abdominal aorta was exposed under general anesthesia, and a 10-mm-wide ePTFE graft was sutured to the earlier graft nub as the conduit. The bilateral CCAs were exposed, and a short 6F sheath was placed in a retrograde fashion into the CCAs, respectively. Through the sheaths, two 0.035-inch guidewires were advanced into the

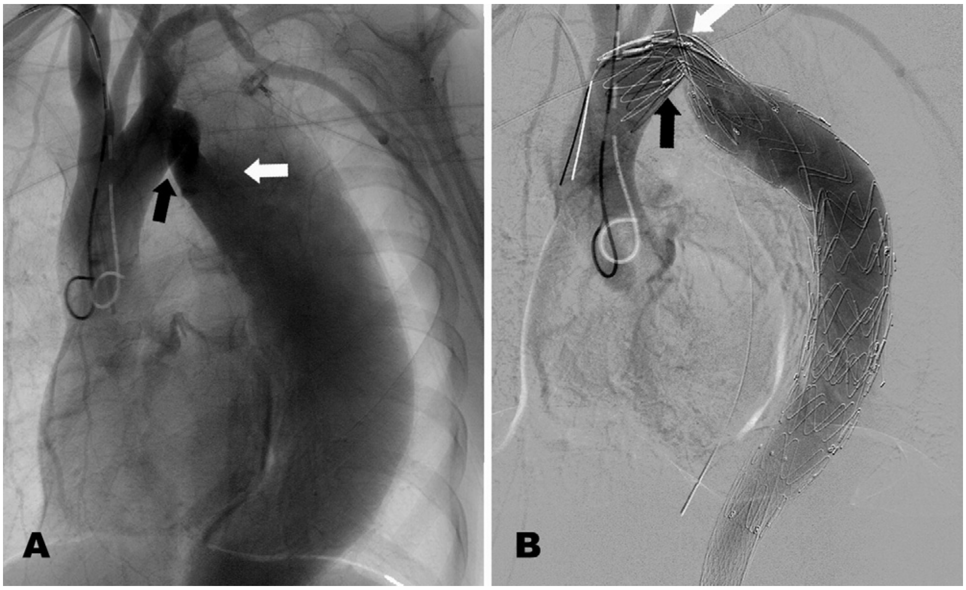


**Fig 1.** **A,** Aortography showing the Stanford type B dissection with the entry tear (*white arrow*) and a severe distal arch stenosis and angulation (*black arrow*). **B,** Aortography after the first thoracic endovascular aortic repair (TEVAR) showing the excluded entry tear with partial coverage of the left subclavian artery (LSA) origin.

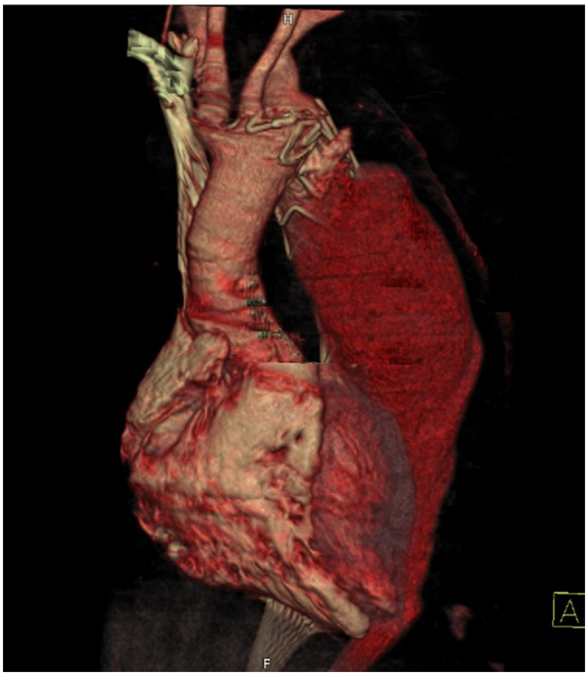

**Fig 2.** Computed tomography angiography (CTA) before double-chimney endovascular repair showing the secondary proximal type 1 endoleak and the large false lumen.

ascending aorta. An 8 mm × 60 mm SINUS stent was delivered in advance, with a short segment protruding into the aortic arch lumen and extending distally into the proximal left CCA (Fig 3, *A*).

Subsequently, a 32 mm × 155 mm Relay stent graft was introduced from the aortic approach until the proximal fabric edge was adjacent to the innominate artery. The endograft repair was completed using standard techniques with complete coverage of the orifices of the innominate artery and the left CCA. The second SINUS stent (size, 10 mm × 60 mm) was then introduced via the right CCA and deployed to open a channel for flow to the innominate artery (Fig 3, *B*). The interruption time of the innominate artery was <20 seconds. Meanwhile, coiling of the central LSA to avoid backflow was performed percutaneously via a left transbrachial approach.

Completion angiography revealed widely patent innominate artery and CCAs, exclusion of the LSA, and no evidence of endoleak, although the arch stenosis and angulation remained unchanged (Fig 3, *C*). The patient awoke from general anesthesia with a completely normal neurological status and showed good recovery without anticoagulation therapy. A follow-up CTA performed 1 year after the second TEVAR indicated no proximal endoleak with complete thrombosis and unreduced diameter of the thoracic aortic false lumen, as well as free flow into the innominate and left carotid arteries (Fig 3, *D*). The devices showed no change in their morphology.

## DISCUSSION

In spite of the development of hybrid procedures[3-6] and fenestrated[7,8] or branched[9-12] stent grafts, the aortic arch is still considered one of the problematic regions in TEVAR. Though these solutions could reconstruct the supra-aortic branches, some drawbacks are clear, such as inevitable conventional surgery, operation difficulty, high risks of cerebral ischemia, and stent graft customizing that is not suitable for urgent cases. Moreover, by these methods, it is difficult to deal

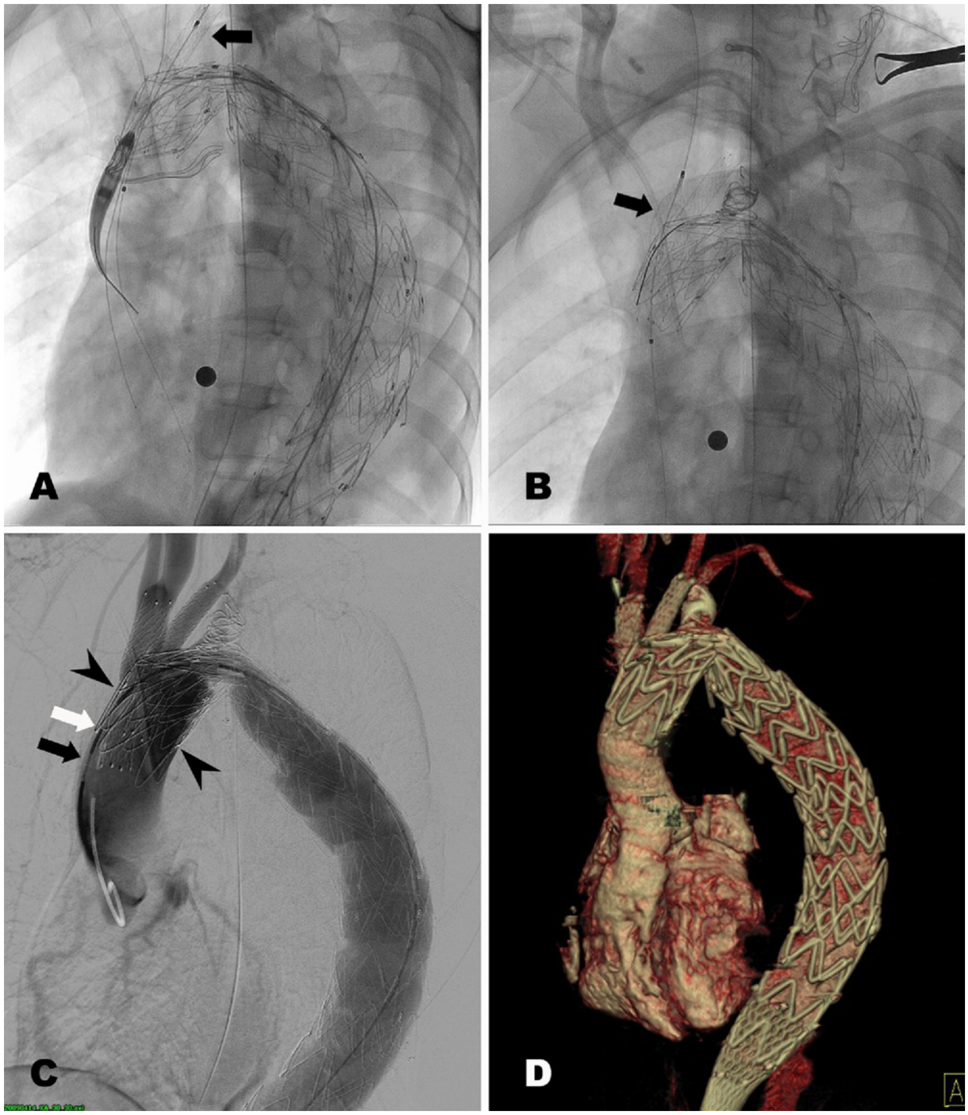


**Fig 3.** Intraoperative fluoroscopic image at the second thoracic endovascular aortic repair (TEVAR) showing: **A,** Deployment of the aortic stent graft and the delivered stent extending from the left common carotid artery (CCA) to the aortic arch (*arrow*). **B,** Deployment of the second stent in the innominate artery (*arrow*). **C,** Completion angiography showing no endoleak into the false lumen, antegrade flow in the innominate and left carotid arteries, exclusion of the left subclavian, and unchanged aortic stricture and angulation. *Black arrow:* proximal end of the stent in the innominate artery. *White arrow:* proximal end of the stent in the left CCA. *Arrowhead:* proximal edge of the fabric of the second Relay stent graft. **D,** One-year follow-up computed tomography angiography (CTA) showing good device morphology and no leakage, patent innominate and left carotid arteries, and complete thrombosis in the descending aortic false lumen.

with certain complex aortic arch anatomies and pathologies, especially type I endoleak after TEVAR. In this case, the proximal bare stent of the earlier endografts, which encroached upon the origin of the innominate artery and the left CCA, interfered with the manipulation of the fenestrated or branched stent grafts. In addition, the anesthetist did not think anesthesia via a laryngeal mask airway is suitable to hybrid procedure through sternotomy.

We, therefore, aimed to develop the double-chimney technology, which is based on a previously reported intentional carotid stenting or double-barrel technique.[13-15] In comparison with these single-chimney techniques, our method can simultaneously preserve the innominate artery and the left CCA and thus ensure a longer landing zone. Moreover, the technique can be performed with noncustom-made devices available in most centers.

Theoretically, the direct interaction between the stents and the thoracic stent graft may lead to deformation or malfunction of one or both. However, in this case, we did not observe such problems for up to 12 months after the operation. We think the stent graft can adequately accommodate the presence of the stents, filling the space between the devices and the aortic wall, with its short independent nitinol rings.

For the stent type, it could be argued that balloon-expandable stents or even covered stents might be better choices.[13,15] Balloon-expandable stents, which are generally selected, offer superior radial strength and allow precise deployment. However, we believe self-expanding stents also have sufficient crush resistance and remain open after placement. The follow-up of the two self-expanding stents is consistent with the results of a few other reports on self-expandable uncovered or covered stents adopted in similar procedures.[13-15] Furthermore, because of the lack of rebound, these stents might compromise the configuration of the aortic stent graft less than the balloon-expandable stents. Covered stents require larger introducers and are more prone to affecting the cerebral blood flow. Therefore, we think the covered stents offer no additional benefit, except that a long channel is required for the branch.

Another issue concerns the deployment sequence of the devices. In contrast to Criado's method,[13] we tended to release one carotid stent prior to the deployment of the aortic stent graft. In our opinion, the optimal sequence can avoid temporary complete interruption of the blood flow to the brain during delivery of the stent graft as well as avert the possibility of angioplasty. While excluding all the arch branches, pre-establishment of at least one carotid artery perfusion is extremely important to avert cerebrovascular events.

In the extremely angulated and stenotic aortic arch, it is difficult to insert a delivery system. The sheath will highly twist in the arch angulation, making graft deployment difficult. We believe most of the delivery systems cannot complete the mission except the Relay transport delivery system, which can smoothly push the stent graft through the angulation in a more flexible inner sheath. Therefore, we chose the Relay products in the two TEVARs, although we always tended to select a stent graft without the proximal bare stent to avert the potential injury related to the presence of an uncovered stent in such a tortuous and steep arch.

## CONCLUSION

We have reported our first experience with the double-chimney technique. Further follow-up for the long-term stability and interaction of these complex devices is required. If our method proves both durable and reproducible, it might offer a new option to simultaneously preserve the innominate artery and the left CCA for total reconstruction of the aortic arch.

## REFERENCES

1. Greenberg R, Resch T, Nyman U, Lindh M, Brunkwall J, Brunkwall P, et al. Endovascular repair of descending thoracic aortic aneurysms: an early experience with intermediate-term follow-up. J Vasc Surg 2000; 31:147-56.
2. Ishida M, Kato N, Hirano T, Cheng SH, Shimono T, Takeda K. Endovascular stent-graft treatment for thoracic aortic aneurysms: short- to midterm results. J Vasc Interv Radiol 2004;15:361-7.
3. Criado FJ, Barnatan MF, Rizk Y, Clark NS, Wang CF. Technical strategies to expand stent graft applicability in the aortic arch and proximal descending thoracic aorta. J Endovasc Ther 2002;9(Suppl II):II-32-8.
4. Szeto WY, Bavaria JE. Hybrid repair of aortic arch aneurysms: combined open arch reconstruction and endovascular repair. Semin Thorac Cardiovasc Surg 2009;21:347-54.
5. Schumacher H, Böckler D, Bardenheuer H, Hansmann J, Allenberg JR. Endovascular aortic arch reconstruction with supra-aortic transposition for symptomatic contained rupture and dissection: early experience in 8 high-risk patients. J Endovasc Ther 2003;10:1066-74.
6. Czerny M, Gottardi R, Zimpfer D, Schoder M, Grabenwoger M, Lammer J, et al. Midterm results of supra-aortic transpositions for extended endovascular repair of aortic arch pathologies. Eur J Cardiothorac Surg 2007;31:623-7.
7. Kawaguchi S, Yokoi Y, Shimazaki T, Koide K, Matsumoto M, Shigematsu H. Thoracic endovascular aneurysm repair in Japan: experience with fenestrated stent grafts in the treatment of distal arch aneurysms. J Vasc Surg 2008;48:24S-9S.
8. Monahan TS, Schneider DB. Fenestrated and branched stent grafts for repair of complex aortic aneurysms. Semin Vasc Surg 2009;22:132-9.
9. Chuter TA, Buck DG, Schneider DB, Reilly LM, Messina LM. Development of a branched stent graft for endovascular repair of aortic arch aneurysms. J Endovasc Ther 2003;10:940-5.
10. Chuter TA, Schneider DB. Endovascular repair of the aortic arch. Perspect Vasc Surg Endovasc Ther 2007;19:188-92.
11. Brar R, Ali T, Morgan R, Loftus I, Thompson M. Endovascular repair of an aortic arch aneurysm using a branched stent graft. Eur J Vasc Endovasc Surg 2008;36:545-9.
12. Wei G, Xin J, Yang D, Liu X, Tai Y, Zhang H, et al. A new modular stent graft to reconstruct aortic arch. Eur J Vasc Endovasc Surg 2009;37: 560-5.
13. Criado FJ. A percutaneous technique for preservation of arch branch patency during thoracic endovascular aortic repair (TEVAR): retrograde catheterization and stenting. J Endovasc Ther 2007;14:54-8.
14. Larzon T, Gruber G, Friberg O, Geijer H, Norgren L. Experiences of intentional carotid stenting in endovascular repair of aortic arch aneurysms – two case reports. Eur J Vasc Endovasc Surg 2005;30:147-51.
15. Hiramoto JS, Schneider DB, Reilly LM, Chuter TA. A double-barrel stent graft for endovascular repair of the aortic arch. J Endovasc Ther 2006;13:72-6.

Submitted Jul 2, 2010; accepted Nov 27, 2010.